

*Potassium.*

0.065	grm.	gave 18.8 c.c. at 0°C. + 760 mm. ∴ mol. wt. =	77.2
0.083	”	22.4      ”      ”      ”	82.7
0.077	”	19.6      ”      ”      ”	87.7
0.075	”	18.5      ”      ”      ”	90.5
0.077	”	20.0      ”      ”      ”	86.0
0.070	”	20.0      ”      ”      ”	78.2
0.077	”	22.6      ”      ”      ”	76.1
0.087	”	26.1      ”      ”      ”	74.4
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			652.8
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Mean molecular weight. . . . . 81.6

*Sodium.*

0.043	grm.	gave 15.1 c.c. at 0°C. + 760 mm. ∴ mol. wt. =	63.6
0.067	”	23.9      ”      ”      ”	62.6
0.047	”	19.2      ”      ”      ”	54.7
0.040	”	17.6      ”      ”      ”	50.7
0.059	”	28.6      ”      ”      ”	46.0
0.040	”	20.4      ”      ”      ”	43.8
0.045	”	23.36      ”      ”      ”	43.0
0.037	”	20.2      ”      ”      ”	40.9
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			405.3
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Mean molecular weight. . . . . 50.66

Four pieces of potassium weighed in iron capsules and thrown into water, gave 84.2 as a mean molecular weight, calculated from the hydrogen evolved. Four pieces of sodium similarly treated, gave 49.8 as a mean. The above experiments show that no great accuracy in the determination of the vapour density of sodium and potassium can be attained by this method of working when vessels of wrought iron are employed. The results are, however, conclusive as regards the *normal character of their respective vapour densities.*

XVIII. “The Physical Properties of Liquid Acetylene.” By GERRARD ANSDELL, F.C.S., Chemical Assistant to the Royal Institution of Great Britain. Communicated by J. DEWAR, F.R.S., Professor of Chemistry, Royal Institution. Received June 12, 1879.

The hydrocarbon acetylene, being the only one of its numerous class which can be formed synthetically by the direct union of its

constituent elements, has an especial interest for the chemist. The chief physical constants of this substance are unknown, although its polymerised modification, benzene, has been very thoroughly studied in its physical relations by Regnault. Having one of M. Cailletet's ingenious pumps for the liquefaction of gases at my disposal in the laboratory of the Royal Institution, Professor Dewar suggested a series of accurate determinations of its physical properties in the liquid state, and the present communication deals with the critical point, the tension of the vapour of the fluid at various temperatures, together with the corresponding densities and coefficients of compressibility.

The only notice on the liquefaction of the gas appears to be a short paper by M. Cailletet in the "*Compt. Rendus*," vol. lxxxv, No. 19, in which he determines the tension of the vapour of the liquid at different temperatures. These tensions, as will be afterwards seen, differ entirely from those obtained in the present paper, one of the reasons appearing to be that instead of using a carefully calibrated air manometer for determining the pressures, he used the ordinary metallic gauge attached to the pump, which is far from being correct.

The pump itself is too well known to need description, suffice it to say, that two of the iron bottles or reservoirs were used, connected with the pump by a piece of fine-bore copper tubing, so as to equalise the pressure, one containing an air manometer registering the pressures from ten atmospheres upwards, and the other the tube filled with acetylene. The two bottles were then placed side by side, and the height of the column of mercury in either read off by means of a cathetometer.

The formulæ used for calibrating the tubes, and also for calculating the volume of the liquefied gas, and the pressure by the air manometer, were those given by Dr. Andrews in his researches on carbonic acid ("*Phil. Trans.*," 1869 and 1876). The method of preparing the acetylene gas was by the action of alcoholic potash on bibromethylene, the disengaged gas being collected in the form of the red acetylide of copper, by passing it into a strong solution of subchloride of copper in ammonia. This red compound, after being thoroughly washed and boiled with distilled water, was transferred to a flask with dilute hydrochloric acid, the gas driven off by means of a gentle heat, and conducted through a strong solution of caustic soda, to free it from traces of hydrochloric acid, and finally through two small U-tubes with fused chloride of calcium. The perfectly pure and dry acetylene was now passed through the tube to be used for its liquefaction in a slow stream for several hours, and the latter carefully sealed off when all the air had been expelled.

The sealing off requires great care, as unless rapidly done, and the pressure removed from the inside (by cooling the tube) immediately

the point is closed, the acetylene becomes rapidly charred and blows out, a small portion of it being consequently decomposed, and thus interfering materially with the accuracy of the results.

The tube for the tension determinations was of the usual shape used in the Cailletet pump, the internal diameter of the capillary part being about 2.5 mm. This was found to be more convenient than a narrower tube, as a larger reservoir could be used, and consequently a larger quantity of liquid obtained.

The pressure at the different temperatures was always observed when a very slight layer of liquid was formed on the surface of the mercury, as the gas not being entirely free from air, the pressure was slightly increased on filling completely the upper part of the tube.

The following are the tensions obtained compared with those of Cailletet:—

Temp.	Pressure.	Cailletet.	
		Temp.	Pressure.
−23° C. ....	11.01 atm.		
−10 ....	17.06 „		
0 ....	21.53 „	+1° C. ....	48 atm.
+ 5.25 ....	25.48 „	2.5 ....	50 „
13.5 ....	32.77 „	10.0 ....	63 „
20.15 ....	39.76 „	18.0 ....	83 „
27.55 ....	48.99 „	25.0 ....	94 „
31.6 ....	56.20 „	31.0 ....	103 „
36 ....	65.36 „		
36.5 ....	65.89 „		
36.9 ....	67.96 „		

The temperatures above zero were kept constant to within  $\frac{1}{10}$ th of a degree, by allowing a constant stream of water to flow over the tube from a reservoir holding about 10 gallons, in which it had been previously thoroughly mixed. The temperature of  $-10^{\circ}$  was obtained by cooling down alcohol with ice and salt, and that at  $-23^{\circ}$  by surrounding the tube with a narrow glass cylinder containing liquid chloride of methyl, which boils constantly at this temperature; this cylinder being again enclosed in a wider one containing a little phosphoric anhydride to prevent moisture from condensing on the sides.

It was thought interesting to compare the tensions of liquid acetylene with those of the saturated vapour of benzene, being polymeric bodies, although having totally different properties. For this purpose curves were plotted for the two substances, that for the benzene being taken from Regnault's results ("Mem. Acad. Sci., Paris," vol. xxvi, p. 420). They do not, however, run parallel to each other, the benzene having a slower rate of increase at low temperatures, but a quicker rate than the acetylene as the temperature

risers. The curves, however, have no appearance of actually crossing at a higher temperature.

The critical point of acetylene, or that temperature at which no appearance of liquefaction takes place, however great a pressure is exerted on the gas, was found after many careful experiments to be  $37^{\circ}\cdot05$  C.

For determining the density and compressibility of the liquid at different temperatures, a tube of much smaller dimensions was used, having a capillary bore of about  $\cdot8$  mm. in diameter, the whole of the tube having a capacity of  $36\cdot3708$  cub. centims. This gave a column of liquid about 15 centims. long when the upper part of the tube was entirely full at  $15^{\circ}$  C.

The density at any particular temperature was taken by forcing the liquid up the capillary tube at that temperature, until the upper part was completely filled; the length of the column of liquid was then read off, its volume calculated, and this observed volume divided into the calculated weight of the gas at zero. They are as follows:—

Temp.		Density.
— $7^{\circ}$ C.	.....	$\cdot460$
— 3	.....	$\cdot456$
0	.....	$\cdot451$
+ $4\cdot4$	.....	$\cdot441$
9 $\cdot0$	.....	$\cdot432$
16 $\cdot4$	.....	$\cdot420$
20 $\cdot6$	.....	$\cdot413$
26 $\cdot25$	.....	$\cdot404$
30 $\cdot0$	.....	$\cdot397$
34 $\cdot0$	.....	$\cdot381$
35 $\cdot8$	.....	$\cdot364$

It has, therefore, about half the density of liquid carbonic acid, and if we take the actual volume of the liquid at  $-7$  as unity, it becomes  $1\cdot264$  at  $+35\cdot8$ , which gives  $\cdot00489$  as its coefficient of expansion per degree, for the total range of pressure; it is, therefore, only about half as expansible as carbonic acid, whose coefficient is  $\cdot010$ , and is not much more expansible than a gas. Comparing the density of liquid acetylene with that of liquid benzene, the latter is found to be almost exactly three times as great as the former at the same temperature; as for instance, at  $0^{\circ}$  C. the density of the acetylene is  $\cdot456$ , whereas that of the benzene is  $\cdot899$ ; the vapour density, however, of the benzene is three times as great, viz.,  $2\cdot704$ .

The apparent compressibility in glass was determined by direct observation, the liquid being forced up in the capillary tube until the latter was completely full, and then the pressure gradually increased,

and the diminution of volume read off at intervals of about 10 atmospheres up to about 180 atmospheres.

Curves were then plotted, showing the volume at different pressures for the same temperature, and from these the coefficient of compression at any temperature and pressure was easily deduced.

*The following tables are constructed from the curves.*

1.—Mean coefficients of compression of liquid acetylene at different temperatures. Range of pressure from 36·62 to 182·68 atmospheres.

Temp. of acetylene.	Coeff.	Temp. of acetylene.	Coeff.
35° C. =	·00085	16° C. =	·00050
28·6 =	·00068	4·4 =	·00038
22·5 =	·00058	0 =	·00025

2.—Coefficients of compression at the same pressure but varying temperatures.

Temp. of acetylene.	Atm. 70.	Atm. 95.	Atm. 120.	Atm. 160.
*49° C. ....	....	·00343	·00169	·00078
*41 ....	....	·00138	·00099	·00076
35 ....	·00171	·00113	·00078	·00065
28·6 ....	·00122	·00083	·00072	·00050
22·5 ....	·00079	·00065	·00057	·00047
16·0 ....	·00066	·00050	·00049	·00035
4·4 ....	·00047	·00042	·00034	·00032
0 ....	·00041	·00036	·00025	·00029

3.—Coefficients of compression at varying pressures and temperatures corresponding to the same volume.

Temp. of acetylene.	Vol. = 97 c.mm.		Vol. = 92 c.mm.	
	Pressure.	Coeff.	Pressure.	Coeff.
*49° C. ....	170·8 atm.	·00080		
*41 ....	137 "	·00085		
35 ....	103·2 "	·00093	.... 175·8 atm.	·00065
28·6 ....	70·0 "	·00120	.... 137·8 "	·00063
22·5 ....	....	....	.... 99·2 "	·00065
16·0 ....	....	....	.... 59·5 "	·00066
	Vol. = 101 c.mm.		Vol. = 89 c.mm.	
	Pressure.	Coeff.	Pressure.	Coeff.
*49 ....	126·3 atm.	·00128		
*41 ....	98·3 "	·00132		
35 ....	72·7 "	·00167		
22·5 ....	....	....	.... 158 atm.	·00054
16·0 ....	....	....	.... 115·6 "	·00056
4·4 ....	....	....	.... 49·7 "	·00058

\* These two experiments were, of course, made above the critical point.

It is evident from the above tables that acetylene is governed by the same laws as other compressible liquids, that is to say, its compressibility increases as the temperature rises, but diminishes as the pressure increases. For instance, at a pressure of 95 atmospheres it is three times as compressible at 35° C. as at 0° C.

The volume being the same, the compressibility appears to be nearly the same at different temperatures, which is really due to the curves at high pressures running nearly parallel, thus introducing a corresponding difficulty in the estimation of small differences.

On comparing the compressibility of liquid acetylene with the results obtained by M. Amagat ("Annales de Chem.," 1877) in the case of benzene, it appears to be about seven times as compressible as the latter body, at a temperature of 16° C., and under a pressure of 40 atmospheres. The comparison could not be carried out at higher temperatures, for whereas M. Amagat reaches a temperature of 100° C. with the benzene, I was not able to go beyond 35° C. with the acetylene.

XIX. On the Origin of the Mineral, Structural, and Chemical Characters of Ophites and related Rocks." By Professors W. KING, Sc.D., and T. H. ROWNEY, Ph.D. Communicated by the TREASURER, R.S. Received May 12, 1879.

(Abstract.)

The authors, beginning with (A) "The different kinds of rocks treated of," in their memoir, divide them into two groups. The first, "Silacid Ophites," is represented by serpentinite (common at the Lizard) and other rocks, essentially composed of serpentinous minerals: it includes a subsection, comprising peridotites and some others, all slightly hydrated. The second, "Silocarbacid Ophites," consists of rocks, which, in addition to serpentinous minerals, contain a mineral carbonate—for example, ophi-calcite: its subsection is represented by hemithrenes. The relation of the first group, through its subsection, to ordinary metamorphic rocks, also of the second group, through its subsection, to carrarites and dolomites is pointed out.

As regards (B) "Their mineral character," it is stated that ophites, &c., embrace some fifty or more different minerals, all containing more or less hydrous silicate of magnesia; in addition to which, dry silicates and carbonates are often present. The relation of these minerals to others, essentially anhydrous, as hornblende, diallage, and peridote, is noticed.

Treating on (C) "The structural character of ophites, &c.," the protean nature of their essential mine al, serpentine, is shown by